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WIRELESS COMMUNICATIONS

Sanjay Tailor

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13. ABSTRACT (Maximum 200 words)

This report deals with the concepts of wireless communications and the methods used to maximize capability within its limited resources. Frequency management and airwave traffic control issues are discussed. This discussion also includes wireless Local Area Networks (LAN) and satellite communications with a brief overview of the Global Positioning System.

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INTRODUCTION

Data communication is the act of exchanging information between two agents. This transmission occurs between a transmitter and a receiver over some transmission media. This media is classified into two groups: guided and unguided. With guided media, the data is sent along a physical path such as a coaxial cable, optical fiber, or twisted wire pair. With unguided media, signals are sent through air, vacuum, or water. This is known as wireless communications.

Wireless devices, which once belonged only to specialty markets, are fast becoming as common as telephones. These devices offer great benefits since they free people from their offices by giving them the ability to transfer information from anywhere. This benefit is leading to an explosion in demand. However, this demand is becoming difficult to meet because of limitations in wireless technology. These limitations are due to the finite space available in the electromagnetic spectrum. Congestion in the electromagnetic spectrum is a serious problem. As the spectrum becomes more crowded, frequency management becomes the main issue of concern. To deal with this problem, a new generation of communication protocols is being developed by a number of different organizations. These protocols will be used to establish rules to maximize the number of users and the amount of data that can be transmitted over a given area.

DISCUSSION

Frequency Management

Congestion in the electromagnetic spectrum has made frequency management issues a major concern for wireless communications. The use of cellular telephones has grown to 14 million in the United States. To combat this problem, the cellular companies are implementing many data compression techniques to meet the ever increasing demands. The cellular telephone system, also known as the Advanced Mobile Phone System (AMPS) has almost reached its capacity in many markets. The industry is applying four frequency management techniques to increase bandwidth and improve transmission quality. They are Time-Division Multiple Access (TDMA), Code-Division Multiple Access (CDMA), Cellular Digital Packet Data (CDPD), and Frequency-Division Multiple Access (FDMA). The Federal Communication Commission (FCC) has allocated a 50 MHz bandwidth for the cellular network. The FDMA technique divides this 50 MHz into 30 KHz wide channels for frequency modulation (FM) communications (fig. 1). This produces 832 available channels with a bit rate of 19.2 kb/s.

Time-Division Multiple Access goes a step further than the FDMA. It uses the same 30 KHz channels, but incorporates timesharing of three different users on each channel. A baseband data-compression algorithm is used which compresses 20 ms of data into 6.6 ms. This creates three slots for each transmission channel. Hence, TDMA provides three times the capacity of FDMA without using additional bandwidth.

Code-Division Multiple Access is a more complicated technique, but can offer significantly more capacity than the TDMA. This technique is currently only in the conceptual stage. With CDMA, a baseband signal is encoded and then modulated over a 1.25 MHz spectrum. The resulting spectrum is a uniform distribution over the entire bandwidth, approximating white noise. At the receiving end, the signal is demodulated and decoded. Here, each user is issued a different code, thus multiple users can share the same carrier frequency.

Currently, TDMA and CDMA are competing technologies. Time-Division Multiple Access development is approximately 1 yr ahead of CDMA. Installations of TDMA systems began in 1994. Installation of CDMA systems is expected to begin sometime in 1995.

Cellular Digital Packet Data is also an effective method of increasing the capacity of cellular technology. The CDPD system is based on the concept of transmitting data in small bursts, called packets, over standard radio waves when the channel is idle. The system would detect the idle moments and transmit data during that time. It would not adversely affect voice communications because if a voice signal was to impede on a channel during data transmission, the system would search for another unused channel and redirect the signal to that channel. Cellular Digital Packet Data equipment enhances cellular technology because it gives the system a capability to transmit both voice and digital data on the cellular network. It would require the user to have a special radio/modem, so the packets can be sent over the cellular network without the use of a cellular phone.

All of these techniques offer significant improvement to the existing AMPS system. Some potentially offer 10 to 20 times the capacity of the AMPS. Several cellular companies are using these technologies in their applications and many others are planning to do so. Bell Atlantic is currently using TDMA and is expected to take advantage of the CDMA once it is fully developed. It is expected that within 4 or 5 yrs, CDMA will have completely replaced AMPS and with the combination of CDPD technology, will provide the capability to transmit both digital data and voice over the cellular network.

Networking

The objective of data communications is to allow any two devices to transmit and receive data through some media. It is not practical for these devices to be directly, point-to-point connected. So, a communication network should be set up to which

multiple stations can be attached (fig. 2). These networks come in the form of local area networks (LANs) or wide area networks (WANs). A LAN is defined as a communication network that connects users within a small area such as an office or company. A WAN is not limited and can connect users throughout the world. An example of the WAN is the internet. The discussion in this report will be limited to LANs. Local area networks provide one of the largest potential markets for wireless technology. The idea here is to add wireless technology, or provide wireless access, to an already existing LAN. This would free users from their desks because they would no longer have to be physically connected to gain access to the network. Radio frequency (RF) and infrared (IR) signals are used to remotely access the LAN, but these signals have range limitations. Radio frequency provides greater range than IR. With the transmission power set at 1 W or less, RF systems usually have an effective range of 150 to 300 ft indoors and 700 to 800 ft outdoors. The IR systems have a range of about 30 to 50 ft. Once the wired LAN is accessed, the range limitation of these signals is no longer an issue and a world of communications is open to the user.

Airwaves Traffic Control

Whenever we are dealing with communication through the air, we must address issues of traffic control to eliminate data collisions and loss of information. With wired LANs, simple collision detection techniques can be used. With wireless LANs, this is not feasible because it is not possible to detect a collision until after the transmission.

There are two types of network controls for implementing traffic management for wireless communications: centralized-control and distributed-control. Centralized-control is where one centrally located station takes firm control over the stations within its vicinity and allows only one station to transmit data at a time. This type of control is shown in figure 3. With this system each station must be equipped with extra hardware and software so that it is capable of providing coordinating functions if called upon to do so. This mode of operation offers low transmission overhead, but the disadvantage is reduced flexibility. With distributed-control, on the other hand, traffic management is the responsibility of each individual station. This provides more freedom and flexible operation for the users, but does suffer from increased transmission overhead and lower overall efficiency. Since the nodes have more control, they must maintain a set of manners so any single unit would not usurp too much of the LANs time.

Before any wireless transmission can be accomplished, there is a procedure or set of rules that must be followed. These rules are established by the Institute of Electrical and Electronics Engineers (IEEE) 802 Committee's working group. This committee develops protocol standards for communications. Protocol 802.11 was developed for use with wireless LANs (WLAN). This standard allows multiple stations to transmit data on one frequency band.

To send data, the first step is to log onto the network. Next, a request-to-send (RTS) signal must be sent which contains information of the address of the destination and the size of the message. The destination station will send a clear-to-send (CTS) message as soon as it is ready to receive. This procedure is known as interstation handshaking. This technique is very successful in eliminating collisions and loss of data because it alerts the receiver, and clears the channel because other nodes are aware that you are transmitting and how long you will be transmitting. After the transmission has been successfully completed, an acknowledge signal is issued by the receiver verifying the receipt of data. This procedure is illustrated in figure 4. Distributed-control uses this RTS/CTS handshake method to control traffic.

Both the central and distributed control techniques have been proven successful, but they have some disadvantages individually. One of the attractive features of the 802.11 protocol is that the two control schemes can be combined for operation in the dual mode. This allows us to take advantage of the strengths of each scheme. A dual mode system uses the distributed-control as its foundation and a central-control is built on top of it. The objective is to offer both types of access to satisfy different network conditions and maximize efficiency. In light traffic, the distributed-control function provides optimum results whereas in heavy traffic, central-control is best. This blended system prevents the need to run two separate protocols. The distributed-control is made the foundation because the basis for this system is to provide flexibility and equal access to each station. Under this system private work groups can be established where each station in the work group would know the other group member's IDs and share a common password. Distributed-control would be the normal mode of operation. If anytime during this operation the traffic becomes too heavy, central-control can be established. The central-control function station will take control of the channel and keep it off limits to the other stations. This is known as the contention-free period. During this time, the nodes do not have access to the channel on their own, they must wait to be polled by the central-control station. This contention-free period can end at anytime bringing the system back to its normal distributed-control mode. This type of switching between the two modes provides increased operating efficiency under varying network conditions.

One of the nice features of these systems is that the nodes do not have to remain stationary. They have freedom to move between access points in what is known as roaming wireless mobil communications. The stations keep track of the access points and automatically select the one with the strongest signal. This is similar to the cellular technology, where the stations jump from one group to another depending on their location.

Satellite Communication

Satellite communication is one form of wireless communication that provides dramatic cost benefits due to the efficiency of satellite broadcast data. Transmissions are broadcast at the speed of light to satellites orbiting 22,300 miles above the

equator. There are two types of satellites used. The most common is the C-band (4-8 GHz) which is used for entertainment, sports, etc. This signal types uses the larger satellite dishes. C-band is what most backyard dish owners use. Ku-band (12.4-18 GHz) is used primarily by businesses for sending both video and digital data. Ku-band dishes are smaller then C-band because the signals are at a higher frequency.

Global Positioning System (GPS) Overview

The GPS is a form of satellite communication that allows users to determine their three dimensional position, velocity, and time 24 hrs a day. It was developed primarily for navigational purposes. The GPS, although used extensively in the commercial sector, is funded and controlled by the U.S. Department of Defense (DoD) and was designed for United States military use. There are three basic parts of the GPS system: the space segment, the user segment, and the control segment.

The space segment consists of 24 satellites, called a constellation, which send radio signals from space. Each satellite transmits on two microwave frequencies, 1575.42 MHz and 1227.6 MHz. The satellites transmit on the same frequency, but the signals are Doppler shifted. Navigation data is carried on both frequencies. There are 21 navigational and three spare satellites which orbit the earth in 12-hr orbits.

The user end of the system is basically GPS receivers that convert satellite signals into position, velocity, and time estimates. The concept is based on satellites acting as reference points and users determining their position on the earth by measuring their distance from a group of satellites. The signals transmitted by the satellites contain accurate position and time information. The receivers measure the time delay for the signal to reach the receiver, which gives the distance from the satellite. This information is processed to solve for ground position, velocity, and time.

The control segment is composed of ground-based facilities that control and monitor the satellites. The master control facility is located at Falcon Air Force Base, Colorado and five monitor stations and three antennas located throughout the world.

The GPS offers two classes of systems for navigational purposes. One is the Precise Positioning System (PPS), which uses special equipment to provide high precision navigational information. This is authorized for Government use only. The PPS signals are encrypted to prevent unauthorized use. The other system is the Standard Positioning System (SPS), which civil users worldwide can use without restriction. The SPS provides an accuracy of approximately 100 m which is intentionally degraded to protect United States national security interests.

Navigation capabilities of the GPS can prove useful in mobil wireless communications. The cost for small civil SPS receivers can be under $500 (1995). Military PPS receivers are many times more expensive. Currently, GPS is used in personal computing, automotive, marine, military, aviation, and surveying applications.

The future of this technology will provide further reductions in size and cost. These improvements will provide new commercial markets for its products, such as personal hand-held units for hikers, cyclists, and tourists.

Market Facts

The United States market for wireless communication equipment reached $2 billion in 1995 and is expected to hit $15 billion in 1998. It is also predicted that the United States market for wireless LANs will grow from $57 million to $900 million by 1998. Currently, there are more than 11 million cellular telephone users in the United States. This explosion in wireless technology has been compared to the tremendous growth that occurred with personal computers over the past decade.

CONCLUSIONS

Wireless communication is the wave of the future and as the explosion in demand continues, congestion in the finite electromagnetic spectrum becomes a serious problem. As a result, frequency management and airwaves traffic control have become the major issues of concern. The cellular industry had developed and successfully implemented several frequency management techniques to increase capacity and improve transmission quality. Providing wireless access to existing wired network is the objective of this technology to overcome range limitations of radio frequency and infrared signals. Satellite communications provide the most cost effective way to distribute signals (audio, video, or digital data) to multiple locations. The Global Positioning System is one application of satellite technology.

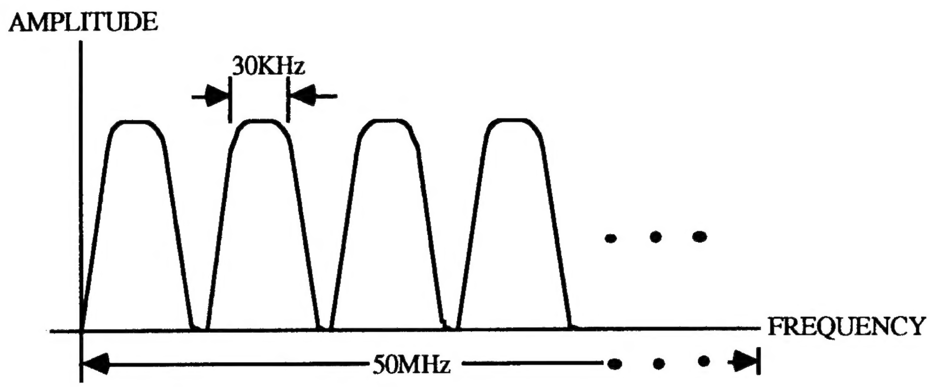

Figure 1
FDMA techniques

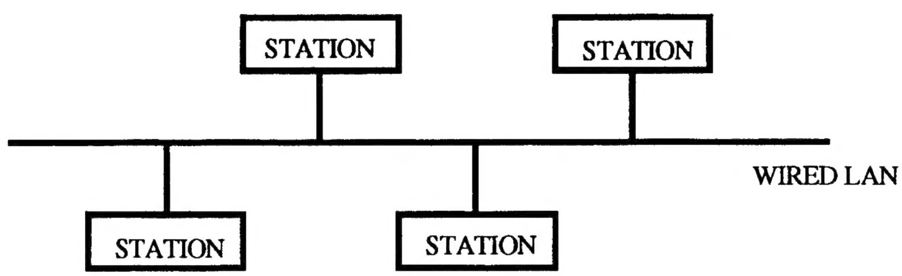

Figure 2
Local area network (LAN)

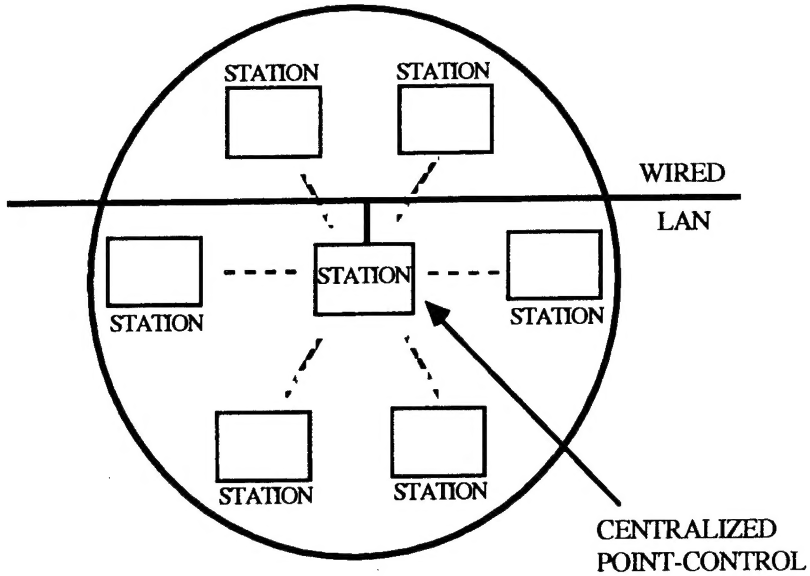

Figure 3
Centralized-control

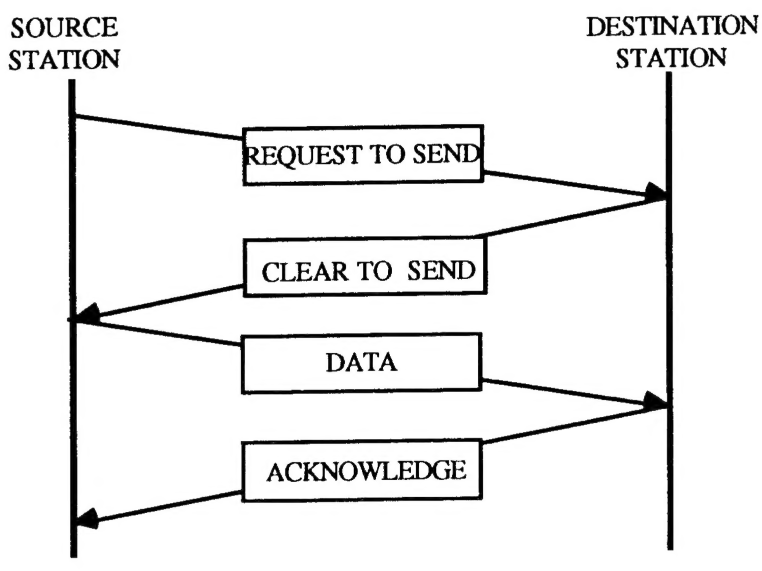

Figure 4
Distributed-control using RTS/CTS handshake

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ATTN: ATRC-WSS-R
White Sands Missile Range, NM 88002

GIDEP Operations Center
P.O. Box 8000
Corona, CA 91718-8000